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Milk composition and factors affecting it in dairy Buffaloes: A review

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Abstract
Dairy buffaloes are higher in milk composition traits. For increasing the productivity of dairy animals, augmenting lactation milk yield has been emphasized, however, the other aspect of milk production i.e. milk constituents such as fat, protein, solid-not-fat, lactose, total solids and casein %, especially β-casein A1 and A2 have so far received little attention in breed improvement programmes. The nutritive value of the milk is based on its component. Nowadays, milk pricing system is also based on the percentage of milk composition, mainly fat, snf, A1 and A2 beta-casein. This change has occurred due to increased awareness of the nutritive values of milk proteins like A1 and A2 beta casein, Omega-3 fatty acid and other non-fatty constituents, in particular minerals like calcium, magnesium and vitamins.

Keywords: Dairy buffaloes, milk, composition, genetic and non-genetic

Introduction
The composition of milk from dairy buffaloes is of major interest to milk processors and consumers because the concentration of certain components in milk affects the pricing policy of milk in the market and thereby directly affect the economy of milk production as well as economic condition of these dairy farmers. Development of breeding programs for changing the composition of milk requires knowledge of the relative influence of genetic and environmental factors affecting milk constituents. However, there is less information on the effects of breed/species [23, 24, 25, 30], stage of lactation [46], parity [18, 46], period or year, season of calving, dry period, body condition score, body weight, pregnancy [26], service period, heat stress, lamness, milking temperament, sex of calf born and sire [12, 15] on milk composition. This can be achieved by an in-depth investigation of all factors affecting the milk composition. Understanding the behaviour of milk components at different stages of lactation will help capture and produce value added health promoting milk and milk products. The effect of genetic and non-genetic factors on the milk constituents of dairy buffaloes is rather scanty under Indian conditions. The present review is therefore, an attempt to analyse the factors influencing milk constituents traits in dairy buffaloes.

Milk Composition
Milk contains the essential nutrients needed for growth and development of human health as well as for the calf. Most common economically important milk constituents traits include fat, protein, snf, lactose and ash (Table 1). Milk is composed of water, proteins, amino acids, vitamins, lipids, fatty acids and minerals, each performs different functions and physiological role. The health consciousness of people, the changing pattern of consumption of dairy products in developed countries and the requirements of dairy product industries and dairy farmers show a growing interest on changing of the amount of different constituents in milk. Studies on indigenous buffaloes have revealed that Indian dairy buffaloes have only A2 allele and hence are a source for safe milk, A2 milk [23, 24]. The A2 allele gene in Indian milk breeds of buffaloes is 100%. A1 β-casein is absent in the milk of pure Asian and African Cattle. Our indigenous buffalo breeds produce A2 milk [23, 24].

Table 1: Milk composition of various breeds of Buffalo.

Buffalo breeds	Fat%	Protein%	Casein%	SNF%	Lactose%	TS%	Reference
Murrah	6.80	3.91		9.61	-	-	Dubey *et al*.,1997
-do-	8.0±0.6	2.70±0.08		8.3±0.3	-	16.3±0.8	Meena *et al*., 2007
-do-	7.7±0.1	3.81±0.02		9.4±0.1	4.83±0.01	17.0±0.1	Sodi *et al*., 2008
-do-	6.99±0.10	3.78±0.03		10.01±0.06	5.37±0.04	16.99±0.12	Sarkar *et al*., 2006
-do-	7.19±0.04	3.46±0.01			4.36-4.6		Yadav *et al*., 2013
-do-	6.65±0.08	4.65±0.05			5.11±0.16	17.23±0.7	Yadav *et al*., 2013
-do-	7.33±0.57	4.14±0.08		9.47±0.07		16.80±0.50	Balusami *et al*., 2015
-do-	7.53±0.19	4.03±0.05	3.20±0.04	9.00±0.07		16.53±0.20	Misra *et al*., 2008
Bhadawari	7.43±0.26	3.92±0.07	3.16±0.06	8.99±0.10		17.70±0.28	Misra *et al*., 2008
Mehsana	6.46±0.17	3.87±0.05	3.07±0.04	9.13±0.06		15.59±0.18	Misra *et al*., 2008
Surti	6.17±0.20	3.93±0.05	3.11±0.04	8.80±0.07		14.96±0.21	Misra *et al*., 2008

Importance of milk constituents

Buffalo milk (BM) plays an important role in human nutrition particularly in the developing countries. Compared to cow milk, buffalo milk is richer in almost all the main milk nutrients. Mozarrella cheese and ghee are the specialties of buffalo milk. In addition, a recent study indicated that people having allergies with cow milk could tolerate buffalo milk. The composition, properties and processing of buffalo milk and milk products has been reviewed by many researchers like [1]. Buffalo milk is characterized by high levels of fat, lactose, protein, casein, and ash contents [1]. Milk fat represents the major constituent of buffalo milk followed by lactose.

Besides these, milk calcium is essential for healthy bones and teeth and helps prevent hypertension. Selenium is an integral component of the immune and antioxidant system in humans. Several bioactive components and essential amino and fatty acids (FA) are available in milk, giving milk a high biological value compared to in meat. Omega-3 fatty acid are associated with prevention of cardiovascular diseases and some cancers. The β-casein composition of the protein fraction has become of special interest recently because of a possible relationship between β-casein genotype and the health of populations of consumers [23, 38, 44]. Genetic variants in bovine β-casein gene (A1 and B) release a bioactive peptide, β-casomorphin-7 (BCM-7) upon digestion, responsible for many human disorders like Type 1 diabetes, autism and heart diseases but A2 milk does not cause such type of illnesses [10, 23, 38, 44]. A1-β casein is also associated with coronary heart disease [20]. But, dairy buffaloes from Asia produce only A2 milk.

Factors affecting milk composition

Milk composition is not constant in dairy buffaloes and is influenced by breed and species differences, parity or lactation order, age and size of the cow, dietary composition, season, pregnancy, Sire, service period, BCS, DP, lamness, heat stress, behaviour or milking temperament, udder health, locality and stage of lactation. The gross composition of buffalo milk is also affected by breed [8, 21, 24, 25, 30, 38, 46], lactation number [8, 17, 18, 30, 38, 39, 46], stage of lactation and seasonality [4, 6, 8, 17, 31, 46] season [6, 28]. Murrah is the best performing breed for fat, total protein and casein contents, Mehsana for solids not fat, and Bhadawari for total solids [24, 46].

Effect of Species/Breed on Milk composition

Buffalo breeds have a significant for all the traits except lactose % [6, 24, 25, 30]. The variation in milk composition within Murrah buffaloes was reported by several researchers [8, 21, 38]. Lower estimate of protein in Murrah buffaloes was also reported [33].

Effect of parity and stage of Lactation on milk composition

The total solids, snf, lactose, and ash content increase with the increase in the number of lactation while the fat and total protein contents are not affected [17, 38]. Lactation number were also found to have highly significant effect (P<0.01) on milk fat %, protein %, total solids %, casein % and significant effect (P<0.05) on 305 days milk yield [39]. There is increase in milk yield up to 5th parity and decline thereafter [18, 46]. Highest milk fat content has been reported during 1st parity [8]. Third lactation is found to be superior to other lactation period in Protein %, Casein % and 305 days milk yield [39]. First lactation was found to be superior to other lactation in milk fat % and total solid % as reported [39]. It was reported that milk fat (8.02±0.12g%) and protein levels (3.51±0.03g) were more in advance parities(7th) indicating significant effect of parity on milk composition and milk lactose increased in second parity compared to late i.e fifth parity [46].

Effect of lactation stage on milk yield, fat and lactose content was also reported to be significant but not protein, lactose increased significantly up to sixth month of lactation, however, changes in milk lactose content was not significant thereafter [46]. Milk yield, % fat, protein and lactose varied from 4.3 to 9.5 kg, 7.19±0.04 to 8.63±0.07 %, 3.46±0.01 to 3.56% and 4.36 to 4.60% respectively during the lactation period as reported by Yadav *et al*., 2013.The content of fat and total solid content increases; lactose decreases, and protein and ash initially decreases before re-increasing with advanced stage of lactation [6, 8, 17, 31]. Milk protein remains lower towards advancing lactation [46] whereas lactose increased to peak of 4.90±0.03 during fourth month and decreased slowly thereafter during the lactation and all other traits of milk composition also differed significantly among months of lactation [8]. It was reported that the respective levels fat, solids not fat, protein and total solids in early, mid and late stage of lactation were 6.47±0.02, 7.09±0.05 and 8.43±0.02 percent, 9.57±0.02, 9.45±0.02 and 9.39±0.03 percent, 3.99±0.02, 4.16±0.03 and 4.27±0.03% and 16.04±0.02, 16.54±0.03 and 17.82±0.03% in graded Murrah buffalo milk [8]. Stage of lactation has a significant effect on fat % and total solids % in the milk of swamp buffaloes and their mean percentages of fat, solids not fat and total solids were reported to be 8.478±0.67, 9.197±0.039 and 17.675±6.088 respectively [47]. The value of fat in swamp buffalo milk were as 8.00 to 10.00 [7] and 9.60 respectively [45].

Effect of pregnancy and Sire on milk composition in buffalo

Significant effect (p<0.05) of pregnancy on milk yield is usually observed from the 5th month of gestation onwards [26]. Decline in milk yield became significant after the 8th week

post-conception, Milk fat increases significantly during succeeding weeks post-conception. Fat concentrations increased linearly from week 2 to 22, while protein showed the opposite pattern in dairy buff aloes SNF and lactose initially decreased up to week 14 but increased later on [16]. Sire of the heifers had a significant effect *P*<0.01) on MY, LP, FY and PY in Egyptian buffaloes [15]. Significant effect of sire on milk composition traits in different breeds of buffaloes had also been reported [12].

Effect of season on milk composition in buffalo

Seasonal variations in the major milk constituents have been reported [6, 28]. Season of calving did not affect the milk composition of Murrah buffalo, however, year of calving was significant for all the traits [8]. The percentages of fat, solids, and solids not fat (SNF) were the highest during summer [6]. The effect of season on milk yield (kg) was found to be significant [46]. Higher fat content with a concomitant decrease in milk yield, decreases to minimum level during winter (7.38±0.03g %) compared with 7.94±0.03g% during summer-humid months [46]. Milk protein level was 3.4±0.24 g% and 3.55±0.20 g%, respectively, in calving during summer, winter- autumn seasons and the seasonal difference was significant [46]. Highest protein% was seen in hot humid season [33].

Effect of BCS, teat and udder characteristics on milk composition

Murrah Buffaloes of BCS group 4.0-4.49 had higher (*P*<0.01) milk fat % followed by BCS groups of 3.5-3.99, 3.0- 3.49 and 2.5-2.99 at 6-8 weeks after calving as well as the 16-18 weeks after calving whereas buffaloes of BCS group. 3.5-3.99 had higher (*P*<0.01) milk protein and SNF % followed by BCS groups of 4.0-4.49, 3.0-3.49 and 2.5-2.99 at 6-8 weeks and at 16-18 weeks after calving [2]. Protein contents increases with increasing BCS upto 3.0 and declines with 3.5 while lactose shows positive trend.

The rear quarters produced more milk with higher fat (4.21± 0.07), protein (3.11 ±0.03) and lactose (4.79±0.03) content than the front quarters (Fat-4.15 ± 0.07, protein- 3.08 ±0.03 and lactose -4.77± 0.02 [3, 5, 11, 41, 43].

Conclusion

It is very much important to determine the milk production potential of dairy animal and milk composition in a lactation curve to improve the milk yield and to obtain desired quality. Increasing the milk production is the ultimate objective of the dairy enterprise. Since, quality of milk is essential for consumption as well as production of good quality dairy products, and the pricing of milk is also based on its quality, it is essential for the milk producers as well as for the consumers to know about the various chemical composition of milk and their health related aspects.

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